§63. Operational Archives of NBI-BL3 in 7th Experiment Campaign

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The NBI-BL3 started operation from 2003 September 1st for 7th LHD experimental campaign. Twenty-four straight hairpin shape tungsten filaments were used in arc discharge inside the negative ion source. Three cesium ovens, where the cesium of 6g enters in each, had been attached. It started seeding cesium vapor in the ion source as for temperature configuration of the oven at 170 degrees from September 4th. The beam of 140keV and 30A generated, on September 12th of 2 weeks later, but breakdowns happened frequently with extraction grids.

LHD experiment started from September 24th 2003, the injection beam was 143keV and 40A (1.7MW) of that time. Figure 1 shows the beam power of all injections in BL3. 5791times beam injections had been done with the BL3 operation of total 25652 times until the end of the experiment on January 22nd 2004. The injection power reached to 2.5MW (158keV) on October 1st, and to 3MW (164keV) on October 31st, but breakdown of the extraction grid was not improved. Filaments were exchanged on November 9th as periodical maintenance. Then we checked inside, many discharged marks were generated on the local area of extraction grid. It was cause that a lube remained, when boring the hole through the extraction grid. After the cleaning, breakdown of the extraction grid decreased in the second series of the BL3 operation. The beam reached to160keV and 48A on November 28th with the two weeks conditioning. On December 10th, the cooling water leaked at the grounded grid of IS3B. We exchanged the one piece of the grounded grid, and operation was reopened. It recovered the beam power of 165keV and 53A on December 18th with one week conditioning. The injection beam power increases to 3.9MW (173keV and 64A) on January 13th 2004, and we achieved the production of high ion temperature of 10keV plasma. The

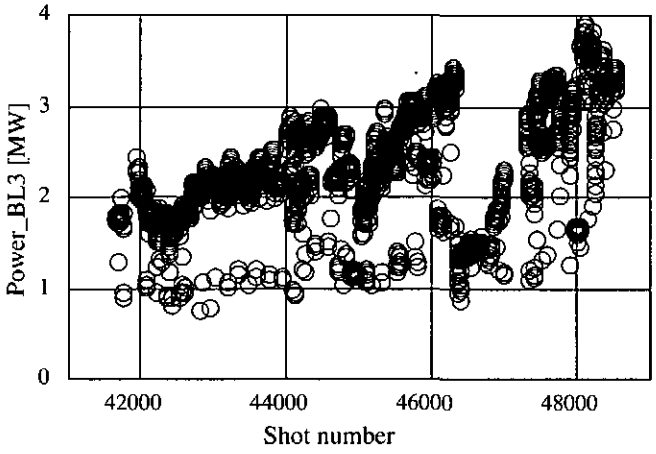

Fig. 1 Progress of the neutral beam injection of the BL3. The beam power of the 3.9MW is achieved in the 7th experimental campaign.

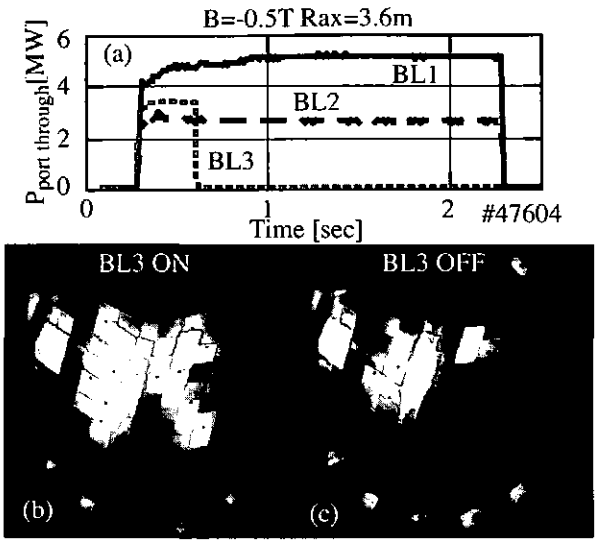

Fig. 2. IR images of the armor tile at the low magnetic field B=-0.5T operation. Neutral beams were injected two secounds (a). Heat load of the BL3 was observed by it's shine through (b). Strong thermal load was observed in local areas (b) at BL3 off.

beam of 37 seconds with the low power of 105keV and 18A had been injected using IS3A only because of the armor trouble.

Local thermal load on the armor tile of BL3 appeared when the case of large out shift Rax=4.05m or low magnetic field Bax=-0.5T. Figures 2 show the IR image on the armor tile taken by IR camera from the inside of the beam line vacuum vessel at the low magnetic field operation of Bax=-0.5T. Usually the carbon armor tile shines with the transmitted component of the beam as shown in Fig. 2(b), and tiles withstand thermal load. After terminating the beam of BL3, strong thermal load was observed locally as shown in Fig. 2 (c). Then crack entered into the tile due to thermal flax from the plasma in the reversed low magnetic field operation on January 7th 2004. The same local heat phenomenon appeared in the large out-shift operation of Rax=4.05m and Bax=1T. It is found by calculating of beam orbit that the particle of co-beam injection, which moves outside of the magnetic surface, hits against the armor tile as shown in Fig. 3. This phenomenon not appeared in the counter-beam injection.

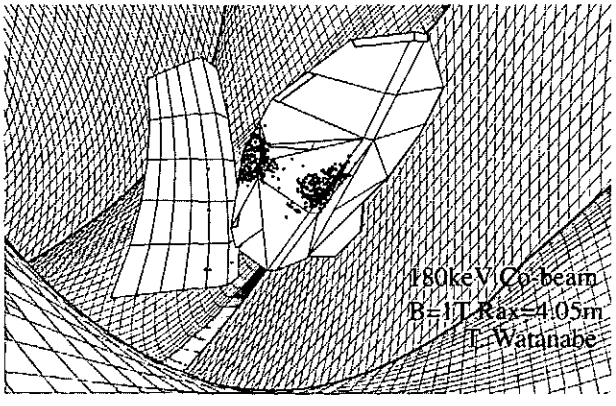

Fig. 3 Co-NBI particles in the case of large outshift Rax= 4.05m and low magnetic field B=1T on the BL3 armor tile